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Waterways Experiment Station

Ship Navigation Simulation Study, New York Harbor, Arthur Kill and Kill Van Kull/Newark Bay

by J. Christopher Hewlett

WES

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Prepared for U.S. Army Engineer District, New York

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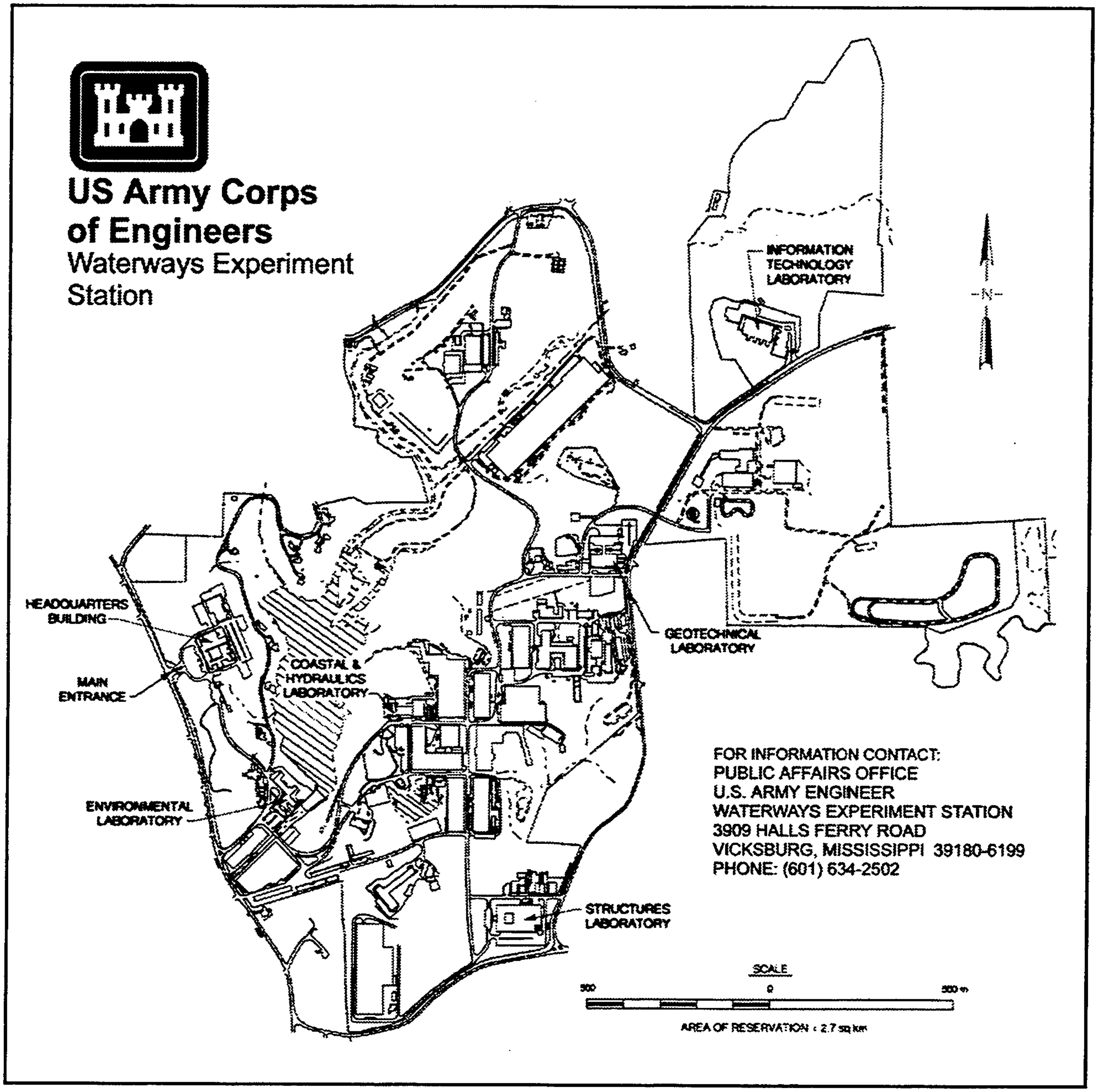

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Contents

Preface

The study summarized herein was conducted during the period June 1987 and October 1988 by Tracor Hydronautics, Inc. (THI), Laurel, MD, and Marine Safety International, Inc. (MSI), Kings Point, NY, under the general supervision of the following from the U. S. Army Engineer Waterways Experiment Station (WES): Messrs. F. A. Herrmann, Jr., Chief, Hydraulics Laboratory, WES; M. B. Boyd, Chief, Waterways Division (HR), Hydraulics Laboratory; and Dr. Larry L. Daggett, Chief, Simulation Group, HR. The study was funded by U. S. Army Engineer District, New York, in support of a deep-draft navigation channel construction project for the Arthur Kill, Kill Van Kull, and Newark Bay channels in New York and New Jersey.

The prime contractor for the study was THI, who conducted the study and prepared the two published contractor reports. The simulation tests were conducted by MSI at the Computer Aided Operations Research Facility (CAORF) installation at Kings Point, NY, under the direct supervision of THI. Mr. J. Christopher Hewlett, Simulation Group, acted as technical adviser and prepared the summary report. Dr. Daggett was the Contracting Officer's Representative for this contract. Dynamic tidal current modeling was performed for the study by Messrs. J. Letter, D. Bach, and T. McCarty of the Estuaries Division, Hydraulics Laboratory.

This report is being published by the WES Coastal and Hydraulics Laboratory (CHL). The CHL was formed in October 1996 with the merger of the WES Coastal Engineering Research Center and Hydraulics Laboratory. Dr. James R. Houston is the Director of the CHL, and Messrs. Richard A. Sager and Charles C. Calhoun, Jr., are Assistant Directors.

Director of WES during preparation of this report was Dr. Robert W. Whalin. COL Bruce K. Howard, EN, was Commander of WES.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
knots (International)	0.5144444	meters per second
tons (long, 2,240 lb)	1,016,047	kilograms

1 Introduction

The U.S. Army Engineer District, New York (CENAN), requested that a ship simulation study be performed in order to establish design guidance for the construction of a deepened and partially widened deep-draft navigation channel in the Arthur Kill, Kill Van Kull, and Newark Bay harbors. The Marine Safety International/Computer Aided Operations Research Facility (MSI/CAORF) simulator at Kings Point, NY, was chosen for the study because much of the visual scene database was already in existence due to former studies of the New York area having been conducted at the facility. One of the primary roles of the U.S. Army Engineer Waterways Experiment Station (WES) was to provide to the contractors tidal current magnitude and direction data from the numerical model developed by the Estuaries Division, Hydraulics Laboratory (Bach, McCarty, and Letter). The WES also developed the scope of work, approved the test plan, monitored the simulator pilot tests, and reviewed and approved the data analysis and reports. The major purpose of this report is to summarize the results and recommendations found in the contractor's reports. Discrepancies between the contractor's findings and those formulated by the WES simulator staff during review of the simulator results are presented. To aid in the discussion, certain figures prepared by the contractors have been extracted, modified, and included in this report. Because the contractor's reports are an integral part of the discussion in this paper and are cited many times, they are listed here for easy referral. Detailed information on database development, test conditions, testing program and procedures, etc., are included in these reports prepared by the primary contractor, Tracor Hydronautics, Inc. (THI) (Roseman and Jakobsen 1988a, 1988b) .

2 Arthur Kill Channel

The purpose of this section is to summarize the design recommendations for the Arthur Kill (AK) project stemming from the ship simulation study. These conclusions and recommendations are the product of a collaborative effort between WES and THI. Figure 1 shows the study area with the existing and the proposed channel alignments depicted. The following paragraphs discuss the recommendations pertaining to each of the reaches in the AK Channel.

North of Shooter's Island Reach and West Bank Entrance to Newark Bay

The proposed changes in this area were designed to provide a two-way deep-draft passing zone north of Shooter's Island as well as to provide increased maneuvering room along the west side of the entrance to Newark Bay. The latter modification is technically considered a part of the Kill Van Kull/Newark Bay (KVK) project but also provides a decided advantage to AK traffic as well, most notably during the difficult task of backing and turning outbound containerships. The simulation study showed that the proposed passing zone in the North of Shooter's Island Reach was adequate with recorded minimum clearances between the passing ship and the test ship generally greater than one ship's beam. The widening along the west side of the Newark Bay Entrance provided more room than is presently available which made turning easier during the outbound backing maneuvers with the containership. For one set of conditions (flood tide and 20-knot[1] SE wind), the simulation study showed approximately a 10-minute reduction in transit time during backing maneuvers in the proposed channel in comparison to the existing channel (Roseman and Jakobsen 1988a). In the other tested condition (ebb tide and 20 knot NW wind), the mean transit time in the proposed channel was not significantly different from that in the existing channel. As a further benefit for backing containerships, it is recommended that the northern channel boundary be moved farther north along the North of Shooter's Island Reach as shown in Figure 2. This change would remove the "dog-leg" in the channel and allow easier backing and turning maneuvers for outbound traffic by eliminating

[1] A table of factors for converting non-SI units of measurement to SI units is found on page v.

the need to rotate counterclockwise before rotating clockwise and entering the Newark Bay turning area. It is reasonable to expect that this modification would reduce the transit time for these maneuvers. In addition, the removal of the dog-leg would provide for easier passing situations for inbound traffic.

North of Shooter's Island Reach Navigation Aids

The simulation study showed that the pilots had difficulty in determining their ship's position in this reach as well as through the Howland Hook bend into the adjacent Elizabethport Reach (Figure 2). In general, the study recommendation is to improve the system of navigation aids in the area. Specific suggestions include reinstatement of the North of Shooter's Island range lights and additional buoys to mark the southern and northern channel boundary in the Howland Hook area.

Elizabethport Reach

The recommendations for this reach include the bend in the channel at Howland Hook. Under the conditions tested in the simulation study, the pilots had difficulty clearing the northwest channel boundary, primarily during inbound runs and conditions of flood tide and SE wind at 20 knots. Although the proposed channel simulation runs for these conditions showed, on average, increased clearance to the northern channel boundary in this reach, the composite tracklines on Figures 3 and 4 show that a number of close calls occurred in *both* existing and proposed channels (Roseman and Jakobsen 1988a, Appendix B). Furthermore, since there is little difference between the existing and proposed channel alignments in the bend and just south of the bend, the pilot runs for the two channels in this area basically tested the same conditions (with the exception of ship draft) and can be considered jointly. With this in mind, the results support the view that as much room as possible should be provided along the northwestern side of this bend for the pilots to negotiate the turn. The specific recommendation (Figure 2) is to follow the existing channel line for a distance of 2,000 ft (approximately two ship lengths) and then return to the proposed alignment just above the railroad (RR) bridge (shown on Figure 1). In addition, the proposed southern channel boundary through the Elizabethport Reach seemed to provide a benefit to the pilots during the simulation runs and is recommended.

Gulfport Reach

Under the conditions tested in the simulation study, this reach, which includes the passage through the RR and Goethals bridges (Figure 1), was one of the most difficult to the pilots. Many groundings occurred on both the east and west banks south of the Goethals Bridge during the inbound runs with the San Clemente tanker. Additionally, the simulator currents in this reach were rated as being stronger than expected by all the pilots (Roseman and Jakobsen 1988a). The consensus is that the simulation channel currents were not satisfactorily validated in this region. If the currents were modeled stronger than would normally be experienced in this area, the groundings and ship tracklines will require more channel width than necessary. The results indicated that for this region there was no significant difference between pilot performance in the existing and proposed channels signifying no degradation of pilot performance for proposed conditions. Due to the restriction of the bridges and development along the bank, very little modification of the channel alignment could be made without great expense, even if the simulation tests had shown the need for improvement; therefore, no specific recommendations for this area are made. The recommended channel in the northern part of the Gulfport Reach below the bridges follows the proposed channel alignment.

3 Kill Van Kull/Newark Bay

For the KVK/Newark Bay phase of the study, WES generally agrees with the recommendations presented by THI (Roseman and Jakobsen 1988b); however, based on additional analysis of the simulator results, further explanation and modification of these recommendations are considered necessary and are presented in this section.

Bergen Point

Bergen Point Area

Although the Bergen Point widening is technically considered a part of the KVK project, AK *and* KVK simulator pilot runs through this area must be considered jointly. Proposed widening in this vicinity represents a sizeable portion of construction cost due to the quantity and type of bottom material that must be removed; therefore, analysis of this area becomes critical because of the possibility of construction cost savings and potential damage if the channel is not adequate. Furthermore, during preliminary discussions this area was perceived as the most likely place in which significant recommendations might result from the simulator study. This perception stemmed from knowledge of the complexities of maneuvers conducted in the area, leading to numerous possible design recommendations, and the fact that a good number of sample pilot runs were anticipated since Bergen Point was common to both phases of the study.

For the entire simulation study 29 runs were conducted through the Bergen Point area in the proposed channel configuration and 25 were conducted in the existing configuration. These runs were conducted under a wide range of test conditions: inbound and outbound transits; ebbing tide, flooding tide; NNW wind at 20 knots, SE wind at 20 knots; existing channel ship draft, proposed ship draft; and containerships and tankers. In addition, ship passing scenarios were implemented at certain points in some of the tests. Overall, the simulator test conditions were rather extreme and, therefore, represent a good test of both channel scenarios. Figures 5- 8 show the tracklines from the pilot testing program (Roseman and Jakobsen 1988a, 1988b). On the proposed channel figures, the

outline of the existing channel has been sketched in order to demonstrate how much of the proposed cuts in the area were used by the pilots.

Figure 5 shows the containership tracklines recorded during pilot testing for the KVK phase of the study. For the inbound runs, a passing situation was tested with a deep-draft ship holding on the western side of Newark Bay Channel just north of the Bergen Point turn. In the outbound runs on Figure 5, another passing situation was implemented with a ship holding at a position underneath the Bayonne Bridge. These passing zones are shown by the shaded blocks on the figures. In the inbound existing channel runs, the pilots showed a tendency to travel fairly close to Bergen Point as they made the turn into Newark Bay. Under the same conditions in the proposed channel, some of the pilots used a portion of the proposed cut as demonstrated by the ship tracklines passing between the existing channel line and the proposed channel line. Based on recorded rudder movements, propeller rotation rates (RPM) and tug forces presented by Roseman and Jakobsen(1988b), it is evident that the pilots used more ship power and less tug power in the proposed channel while making the inbound turn around Bergen Point. To quantify this, a control measure known as the maneuvering factor can be examined. The maneuvering factor is calculated by multiplying the rudder angle at each time step with the recorded RPM. This gives a relative measure of the amount of turning power the ship is exerting due to its own power. The average value of the maneuvering factor for all inbound existing channel runs during the main part of the turn is 558 revolution-degrees/minute (RDM); the average value for the proposed channel in the same region is 703 RDM, an increase of 26 percent. This is a fairly significant indication that the pilots generally were using more ship turning power. At the same time, recorded average tug-induced moment through the inbound turn dropped in the proposed channel runs from an existing channel value of 13,872.0 long-tons-ft to 9,703 long-tons-ft, a reduction of 30 percent. The combined effect of these forces resulted in approximately the same average turning rate (change of heading per unit time) for the ships in both channel scenarios. This supports the view of an increased safety margin in the proposed channel in this area because the ship can make the turn more on its own power and the attendant tugs have more reserve power for use during critical situations. Although this shows that the southern portion of the proposed widening at Bergen Point seems to be of benefit for inbound transits into Newark Bay, the northern portion of the same cut resulted in no advantage for either inbound or outbound transits. Also, the pilots did not use this area of the channel during the outbound backing maneuvers conducted during the AK phase of the study (Figure 6); therefore, only the southern portion of the proposed KVK Bergen Point cut is recommended.

Directly opposite the Bergen Point cut, the proposal calls for a small widening of the channel at the eastern end of the Shooter's Island shoal. A comparison of the existing and proposed alignment in this area can be seen in Figure 5. An effort was made during the simulator scenario development to create a situation in which the pilot would have to steer outbound ships as far to the west and south as was possible in order to test the merits of channel widening on the west side of the Newark Bay entrance. This scenario involved passing a ship underneath the Bayonne Bridge after the turn, thus forcing the pilot to get the ship on the southern

edge of the KVK Channel in the bend. While all the runs were completed successfully without collision, the test conditions did have the desired effect and quite a number of the pilots ran out of the channel on the south side near the bridge. Despite this, only one pilot testing in the existing channel came close to the channel buoy (#17) near the eastern end of the Shooter's Island shoal and the clearance to the buoy was still approximately a full ship's beam. This occurrence seems to contradict the perception of the test pilots, three of whom wrote comments supporting the widening (Roseman and Jakobsen 1988b). Due to this conflicting evidence, it seems prudent to recommend some, but not all, of this particular widening (Figure 9). Focusing on another area, it is significant that a passing situation underneath the Bayonne Bridge is not actually attempted frequently and, according to the pilots, is to be avoided if at all possible. If the conditions tested (strong ebb tide and NNW wind) in the simulation study were more common, widening along the southern channel boundary in the vicinity of Bayonne Bridge would have to be considered. As it stands, no specific recommendations will be made for this area. On the other hand, speculation can be made concerning the path of tracklines for similar outbound runs in the more likely event that passing under the bridge will not occur. It seems reasonable to expect that the pilots would be able to transit further north and in so doing take advantage of the southern part of the Bergen Point cut.

Figures 6, 7, and 8 show pilot tracklines for the AK transits through the Bergen Point area. These were excerpted from Roseman and Jakobsen (1988a) and, again, the existing channel alignment is sketched on the proposed channel figures. These plots demonstrate the need for further widening along the southernmost boundary of Bergen Point because of an advantage to AK traffic. On Figure 6 the composite outbound backing maneuvers show that after making the turn, the point at buoy "14" (Figure 9) is still an obstacle to avoid, even in the proposed channel. If this point were cut back further, the turn into the Bayonne Bridge could probably be made easier and safer. On Figures 7 and 8, the AK inbound runs are shown for which the *proposed* channel scenario is of primary concern because of the simulated passing situation implemented in the Shooter's Island passing area (the existing channel does not have a passing area because it does not allow two-way traffic). It is evident by the angle of the tracklines in the area near "14" that the ship is steering very sharply at this point in order to get farther north in the channel for alignment in the passing zone north of Shooter's Island. One of the AK test pilots stated (Roseman and Jakobsen 1988a) that the approach for the passing would require a "right turn" at Bergen Point. This turning procedure becomes even more critical during the NNW wind/ebb tide simulation demonstrated by the southward shift of the composite trackline in the passing zone (shaded area) when compared to the SE wind/flood tide case. A wider cut near buoy "14" would allow the pilots to make the turn earlier at Bergen Point in anticipation of passing another deep-draft ship in the North of Shooter's Island Channel. This cut-back would tend to make the proposed passing area safer and more efficient.

Recommendations

Figure 9 shows the recommended channel alignment in the Bergen Point area. The primary recommendation is around Bergen Point itself and basically represents a rotation of the proposed channel cut to the south. On Figure 9 each recommended channel boundary is labeled with the project for which it provides the most benefits. The widening range of 100 ft to 200 ft on the southern side of Bergen Point is recommended in order to provide leeway for a compromise between channel construction costs and improved navigation conditions. A compromise between these two considerations becomes critical in this area because the bottom material in the Bergen Point area is hard rock. In general, a widening was recommended based on extrapolation of results from simulator pilot tests in the area and, therefore, is dependent on certain suppositions of future operations and pilot performance in the event of construction and cannot be verified without additional simulator runs to specifically test the widener and related change in approach strategy. Widening of 200 ft is the most desirable based on engineering judgment; however, this does not categorically preclude widening of less than 200 ft if widening to 200 ft is not economically feasible. Furthermore, the widening was not recommended based on the existing channel alignment being evaluated as a safety hazard but solely as an enhancement for more efficient and safe shipping operations. A widening of less than 100 ft would probably be ineffective.

Kill Van Kull/Newark Bay

The objective of this section is to present final channel design recommendations, and supporting information, concerning the KVK channels (Figure 10), excluding the Bergen Point area discussed earlier. Supporting evidence for these recommendations is based on data presented in Roseman and Jakobsen (1988b). In some instances the recommendations presented here differ from those in Roseman and Jakobsen, Appendix A (1988b). These differences are a result of a reexamination of the data at WES. In the following discussion, a review will be made of the simulator tests and their impact on Newark Bay South Reach, Newark Bay Middle Reach, the entrance to Port Elizabeth, Port Newark Pierhead Channel, the entrance to Port Newark Channel and the main KVK Channel.

Entrance to Port Newark Channel and Newark Bay Channel

Figures 11 and 12 show, respectively, the existing and proposed channel composite tracklines for the simulated containership scenario outbound from Port Newark Channel. These tests were conducted with maximum ebbing tidal currents and a 20-knot NNW wind. Figures 13 and 14 show composite track plots for inbound containership runs under the conditions of maximum flooding tidal currents and a SE wind at 20 knots. For the tests shown in Figures 11 and 12, one

deep-draft passing situation occurred. The passing area is shown on the trackplots by the shaded area. The inset associated with the passing situation depicts the orientation and approximate location of the traffic ship. Data from Roseman and Jakobsen (1988b) show that the mean ship-ship clearance during the passing situations on Figures 13 and 14 actually dropped in the proposed channel to 227 ft from an existing channel figure of 273 ft (Roseman and Jakobsen 1988b, Tables 4-12). This difference is a result of one run under proposed conditions with pilot #1 in which the traffic ship was located farther west thereby causing a relatively smaller ship-ship clearance (Roseman and Jakobsen 1988b, Appendix A). This circumstance happened because the position and track of the traffic ship are controlled manually at CAORF and the test ship was traveling at different speeds causing the passing position to vary from run to run. These results indicate that the passing situation was handled equally well in both the existing and the proposed channel. Furthermore, it is evident that the pilots essentially followed the same path for both existing and proposed channels throughout Newark Bay Middle Reach down to the region of channel realignment opposite Port Elizabeth. South of this point the pilots were able to steer a straight course in the proposed channel because of the channel realignment and the removal of Port Elizabeth Shoal. Overall, the test results indicate that there was no significant difference in pilot performance in this area for the existing and proposed conditions. In addition, the inbound passing situations (Figures 13 and 14) were handled without incident and with mean ship-to-ship clearances ranging from 188 ft in the existing channel to 307 ft in the proposed.

The General Design Memorandum (CENAN 1986) shows that the width of the proposed Newark Bay main channel (Middle and South Reaches) was designed for two-way deep-draft traffic according to engineering design criteria (Headquarters, U.S. Army Corps of Engineers (HQUSACE), 1983). It is evident that the proposed channel width of 800 ft was obtained with the assumption of a channel with strong yawing forces and/or with rock on the bottom. Although currents tested in the simulation for the Newark Bay Main Channel did approach 1.25 knots, they were generally in line with the channel and did not cause significant vessel drift angles. Therefore, since the simulator conditions tested were fairly extreme with spring tide and significant wind, strong yawing forces do not appear to be predominant in the Newark Bay Main Channel area. Furthermore, the General Design Memorandum (CENAN 1986) indicates soft bottom material throughout Newark Bay north of Bergen Point. With this in mind, it is reasonable to recommend that the minimum allowable bank clearance be decreased from 157 to 100 ft. This results in a recommended reduction in new channel width to approximately 700 ft from the proposed 800 ft. This recommendation generally agrees with that presented in Roseman and Jakobsen (1988b); however, there are some points of disagreement concerning the Newark Bay Main Channel. These disagreements will be discussed in the following paragraphs.

First, there is an indication from the track lines shown on Figures 11-14 that widening to 800 ft *is* needed in the vicinity of the former railroad bridge north of Bergen Point. During inbound runs there was a tendency for the vessels to swing wide around Bergen Point and approach the constriction on the western side. During outbound runs the pilots tended to favor the same western side in

preparation for the turn around Bergen Point. By this indication, maintaining a width of 800 ft in this vicinity will improve navigational safety.

A second disagreement involves the decision whether or not the large shoal area in the vicinity of Port Elizabeth Pierhead Channel is removed. The simulation study centered exclusively on navigation within the authorized channel through Newark Bay because the shoal area was too large for inclusion in an effective simulation testing program. The General Design Memorandum (CENAN 1986) discusses in detail the need for adequate maneuvering and anchoring room in the Newark Bay vicinity because of traffic congestion; however, simulation would not have been effective in defining the amount of room required. This leads to two possible channel configuration alternatives. Figures 15 and 16 show the two alternatives, which do not differ significantly with the exception of the location of the western channel limit in the event that only a portion of the shoal is removed. The primary difference between these recommendations and those presented in Roseman and Jakobsen (1988b) concerns the straightening of the channel. Roseman and Jakobsen (1988b) states that no advantage in straightening was indicated during the simulation. While this may be true based solely on the simulation tests, reasoning and judgment can be used in support of the straightening. First, in the event that the shoal is not removed, two bends (albeit small) along the eastern side of the channel would be required in order to maintain the existing alignment. Ship passing was not tested in the simulation in the immediate vicinity of these two bends; however, it can be reasoned that with a 700-ft channel width, straightening in this area would improve the safety of passing situations by removing the necessity to pass in bends. With channel straightening, a uniform passing zone would be established over the entire Newark Bay Middle and South reaches. Second, in the event that the entire shoal is removed to provide maneuvering and anchoring room, there would be no reason to maintain the eastern channel limit in its present position. Finally, in consideration of the Port Elizabeth Pierhead Channel, in the event that the shoal is not removed, the proposed widening dimension of 10 ft, from 290 ft to 300 ft, is below the level of attainable simulator resolution and therefore no recommendations can be made.

Port Elizabeth Channel

Figures 13 and 14 also show the results of the inbound containership runs with the turn into Port Elizabeth Channel. In the existing case, the inbound ship passed a ship holding within the pierhead line along the eastern end of Port Elizabeth. In the proposed scenario the traffic ship was in the same holding location except outside of the pierhead line. As can be seen, under the conditions of flood tide and SE wind at 20 knots, the pilots had trouble staying within the northern channel limits after the turn in both the existing as well as the proposed channel. In the proposed scenario (Figure 14) one of the pilots went completely out of the channel; however, this can be discounted as an invalid run because it was found that this particular pilot was very unfamiliar with these types of transits, having piloted only one 950-ft containership into Newark Bay during his career. In composite, ship-to-ship clearance for both scenarios under these conditions was

adequate. Analysis of control measures in the channel segment in which the pilots were executing their turn shows a small drop in the maneuvering factor (propeller RPM multiplied by the rudder angle) in the proposed channel, indicating an easier turn. These data tend to support the proposed widening in the Port Elizabeth Channel; however, it is evident that additional room is needed in order to ensure safe operations during flooding tide. Figures 15 and 16 show a recommendation for additional widening in this area. As an alternative to extra widening in the Port Elizabeth Channel, the two operational safety measures listed in the excerpted recommendations (Appendix A, paragraph 5.2.4) can be enacted in order to ensure safe navigation.

Port Newark Pierhead Channel

For this portion of the channel, a 100-ft widening is proposed, from 200 ft in the existing case to 300 ft as proposed. Because of the unavailability of a suitable ship model, no simulation testing was planned or conducted in this reach. Generally, the ships frequenting this channel are bulk carriers in the process of docking or departing. These processes require tug assistance, slow ship speed, and adequate maneuvering room. The General Design Memorandum (CENAN 1986) indicates that the minimum bank clearance presented in the design criteria (HQUSACE 1983) was used for channel width design. Since tugs will be present during movements in this channel, it is reasonable to provide enough room for them to maneuver alongside the ship with the consideration that other ships are moored along the dock and in close proximity. Therefore, in the absence of simulated maneuvers, it is recommended that the proposed width of 300 ft be maintained.

Main Kill Van Kull Channel

Four areas are of primary concern in this part of the channel, three of which have proposed changes. These are, the expansion of the KVK entrance, the widening on the south side of the channel between buoys 7 and 3 adjacent to St. George, and the small widening on the north side of the channel near Constable Hook. The fourth area of interest is part of the Bergen Point East Reach where no modification is planned but through which simulation tests took place. Figure 17 shows the vicinity of the first three proposed channel improvements. Figure 18 encompasses the vicinity of the fourth area. Figure 17 consists of the composite trackplots for inbound and outbound transits in the existing channel as well as the proposed channel. All these runs were conducted with a loaded tanker (although with a deeper draft in the proposed scenario). During the inbound runs, a four-way passing situation was tested near the entrance with an outbound tanker, an outbound shallow-draft tug/barge, and a passenger ferry crossing the channel. During the outbound runs, a passing situation was tested with an inbound tanker heading toward a dock at Constable Hook as the test ship rounded the Constable Hook bend. The inset on Figure 17 only shows the deep-draft traffic ship for the

outbound pilot runs. For the inbound runs the traffic ship was on the same track but in the opposite direction. For the inbound runs, data from Roseman and Jakobsen (1988b) show that mean ship-to-ship clearance between deep-draft vessels during the passing situations increased in the proposed channel to 415 ft from 284 ft in the existing channel, i.e., an increase of more than one ship beam. While this would obviously be a welcome improvement, the clearance value recorded in the existing channel tests is adequate for safe channel operations. Therefore, the expansion of the entrance to KVK cannot be recommended based on the tested simulator scenario. However, the General Design Memorandum (CENAN 1986) discusses that the entrance to KVK from the Anchorage Channel is used for a wide variety of purposes, such as turning, shortening of tows, etc. This being the case, design of effective simulation testing becomes difficult. The simulation results do not provide support for the expansion of the entrance to 2,000 ft; therefore, it is recommended that any possible reduction in that width be implemented.

The passing situation during outbound runs (inset on Figure 17) was completed without complications in both the existing as well as the proposed channel. The pilots never used the proposed cut between buoys 3 and 7 on the south side of the channel during these passing operations. The mean ship-to-ship clearance recorded during these tests ranged from 319 ft in the existing channel to 351 ft in the proposed channel. The minimum ship-to-ship clearance of 192 ft was recorded in the existing channel. However, this part of the channel is designed for three-way passing, which was not tested in the simulation. Possibly, in the event of a three-way situation the proposed cut would provide a benefit to pilots. Although Roseman and Jakobsen (1988b) does not discuss the need for widening in this area, there is evidence that the worst case scenario was not tested; therefore, in the absence of other information, the widening is recommended.

The small widenings on the north side of the channel adjacent to Constable Hook were not recommended by Roseman and Jakobsen (1988b); however, upon reexamination of the results, it is evident that some advantage would be provided to the pilots by this widening. Although bank clearance data are not available, it is clear from Figure 17 that the edge of the channel in this region was approached very closely. Drill hole boring reports in the General Design Memorandum (CENAN 1986) indicate that while the bottom in this region is not rock, it is sand and therefore could pose a danger to navigation. In addition, the area slated for widening is small and, therefore, is recommended.

The last area of concern in the KVK Channel is depicted on Figure 18, showing the composite trackplots for the existing as well as the proposed scenarios. The northern side of the channel is of particular concern here because the bend in the channel causes the pilots to stay close to the north edge during a passing situation as was tested in the simulation. Although this area was not the focus of any analysis or recommendation in Roseman and Jakobsen (1988b), it is evident that the pilots came close to the channel edge in both the existing as well as the proposed runs. Data in Roseman and Jakobsen (1988b) do show that minimum recorded ship-to-ship clearances were on the order of one ship beam in both channel scenarios, although mean ship-to-ship clearances were closer to two

ship beams. With increased room on the northern side of the channel, the safety margin during passing scenarios would be improved. A widening of 50 ft on the north side is recommended for the purpose of ensuring that adequate clearance to moored ships along the south side is maintained.

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Figures

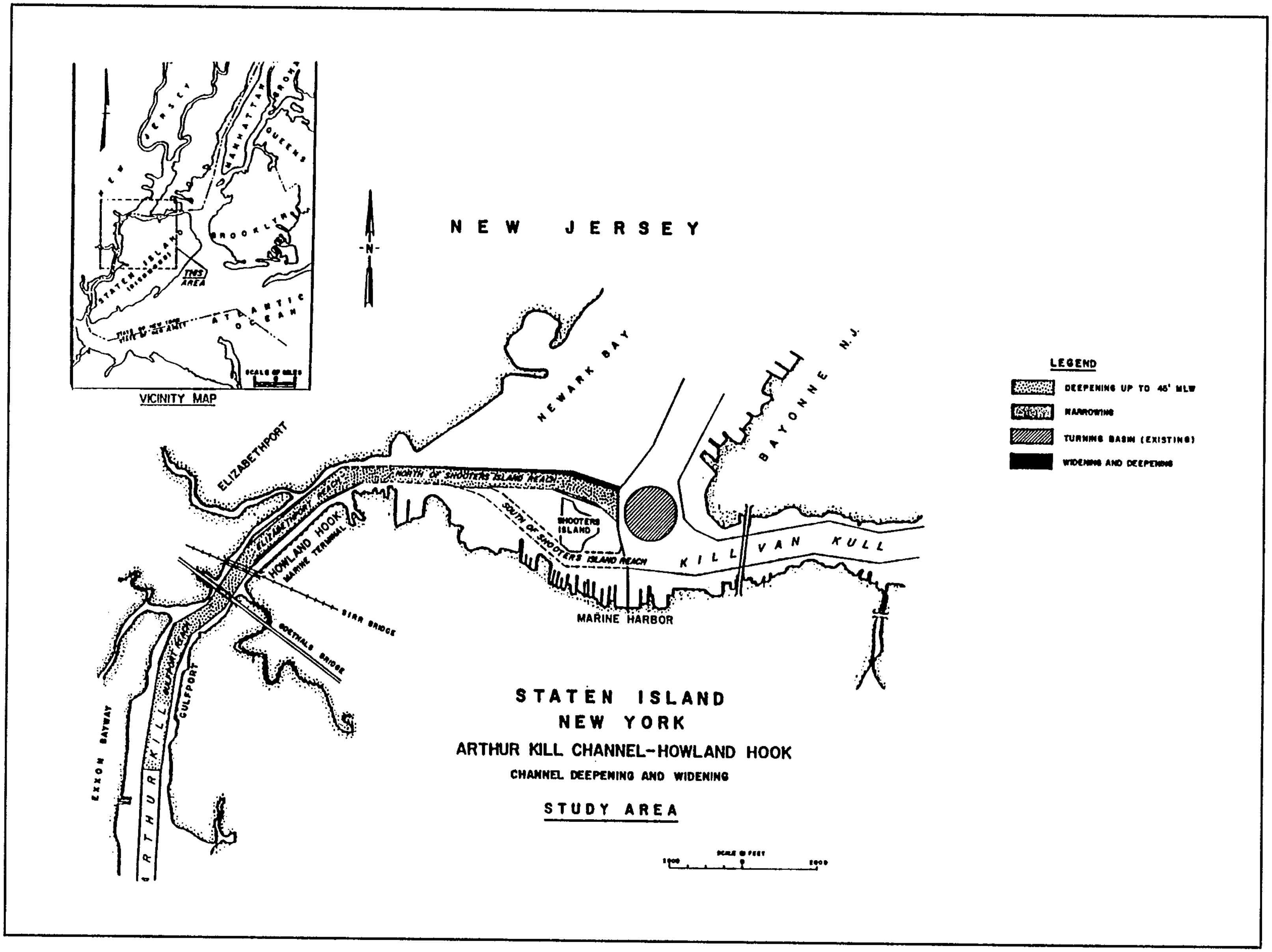


Figure 1. Arthur Kill Channel study area

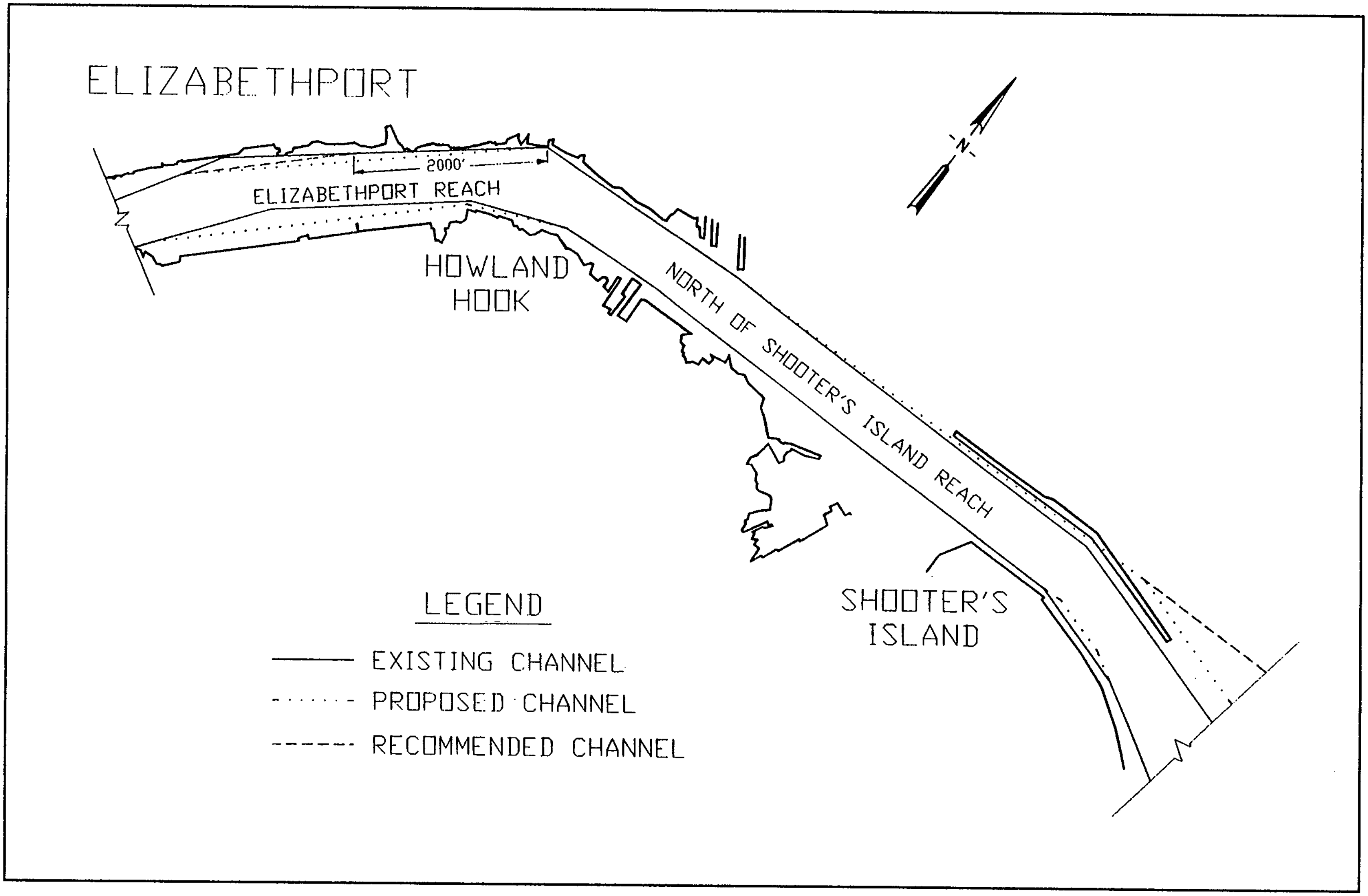


Figure 2. Part of the Arthur Kill Channel

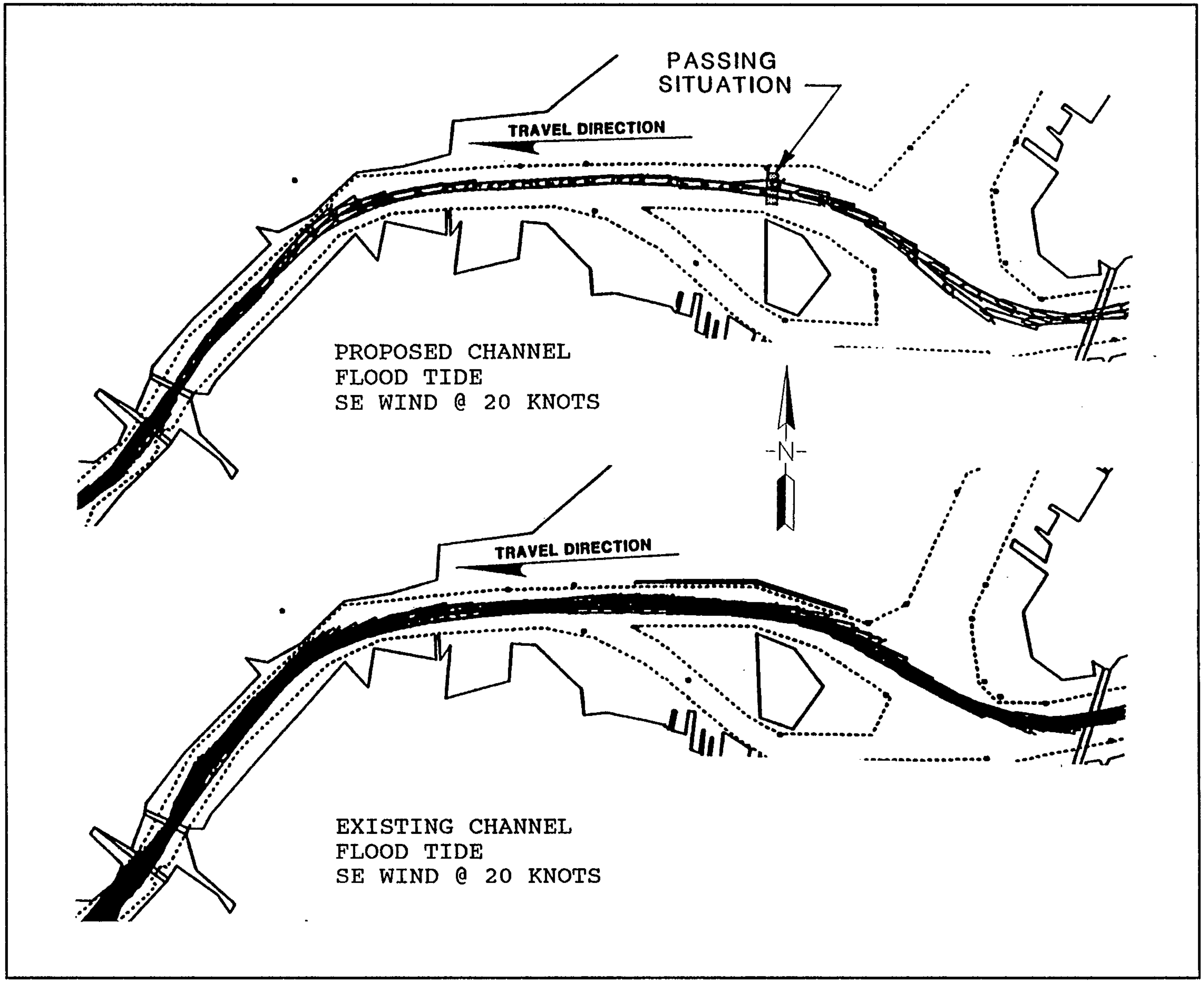


Figure 3. Complete trackplots for simulated inbound containership transits

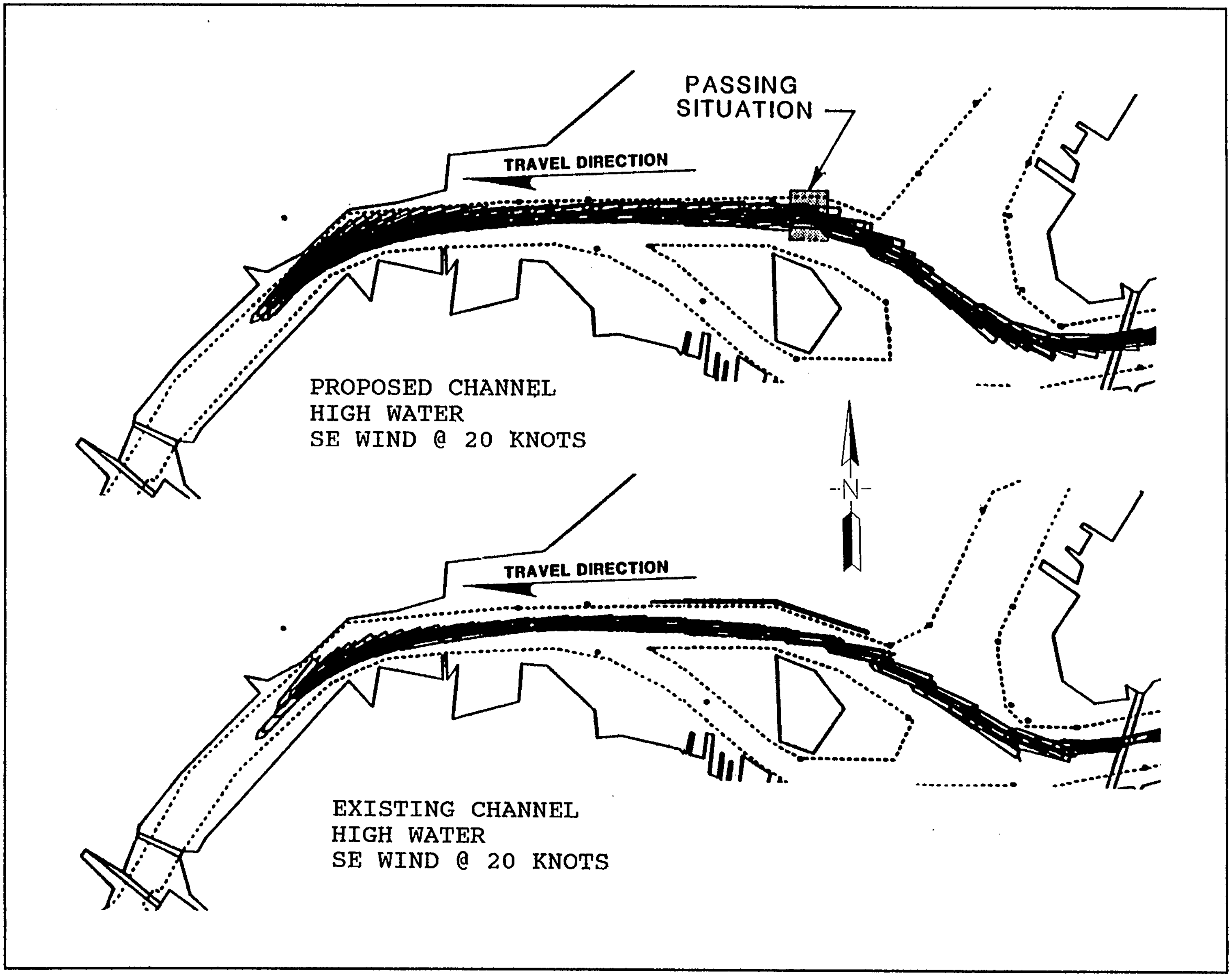


Figure 4. Composite trackplots for simulated inbound tanker transits

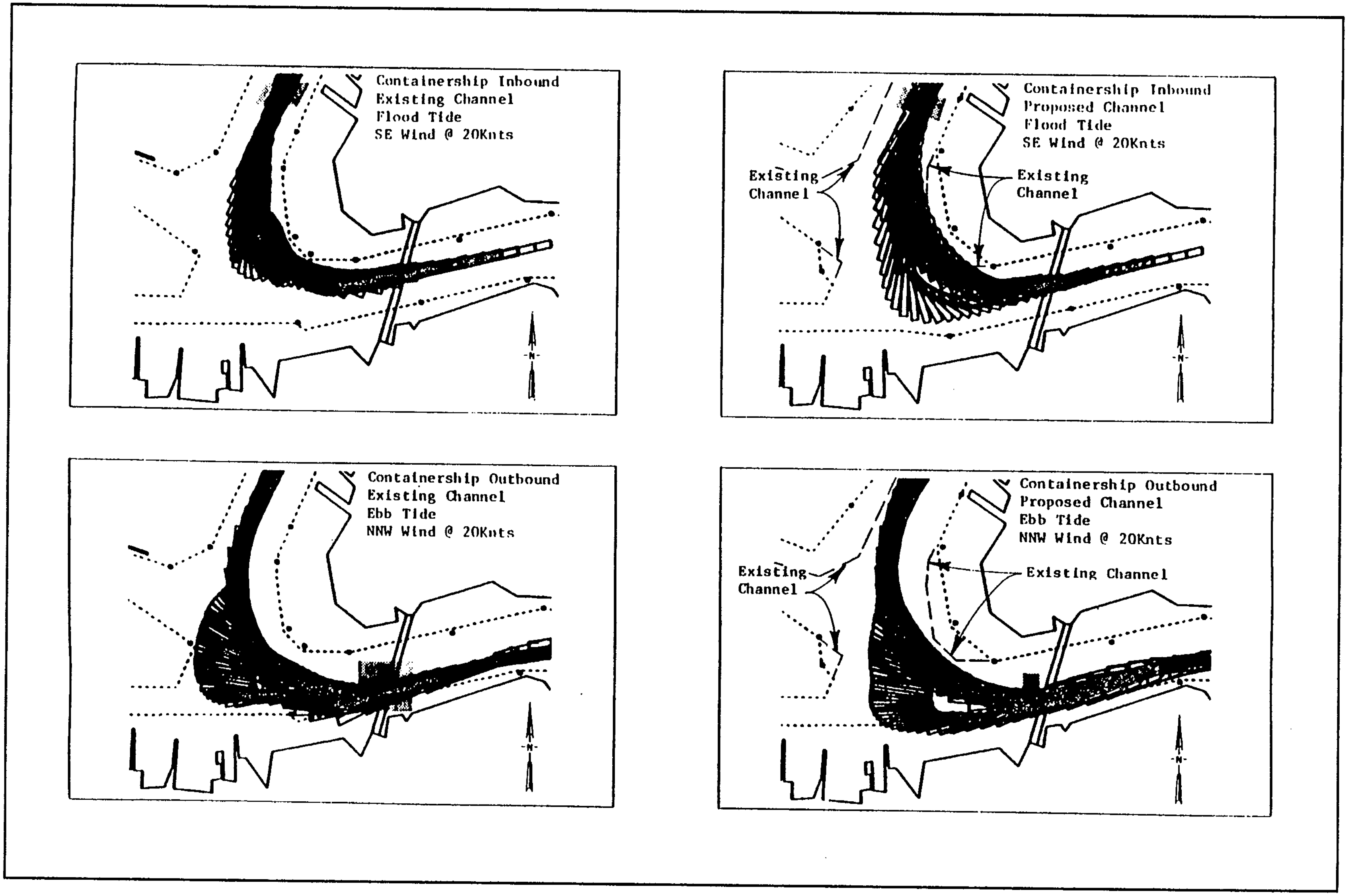


Figure 5. Composite trackplots for KVK pilot tests

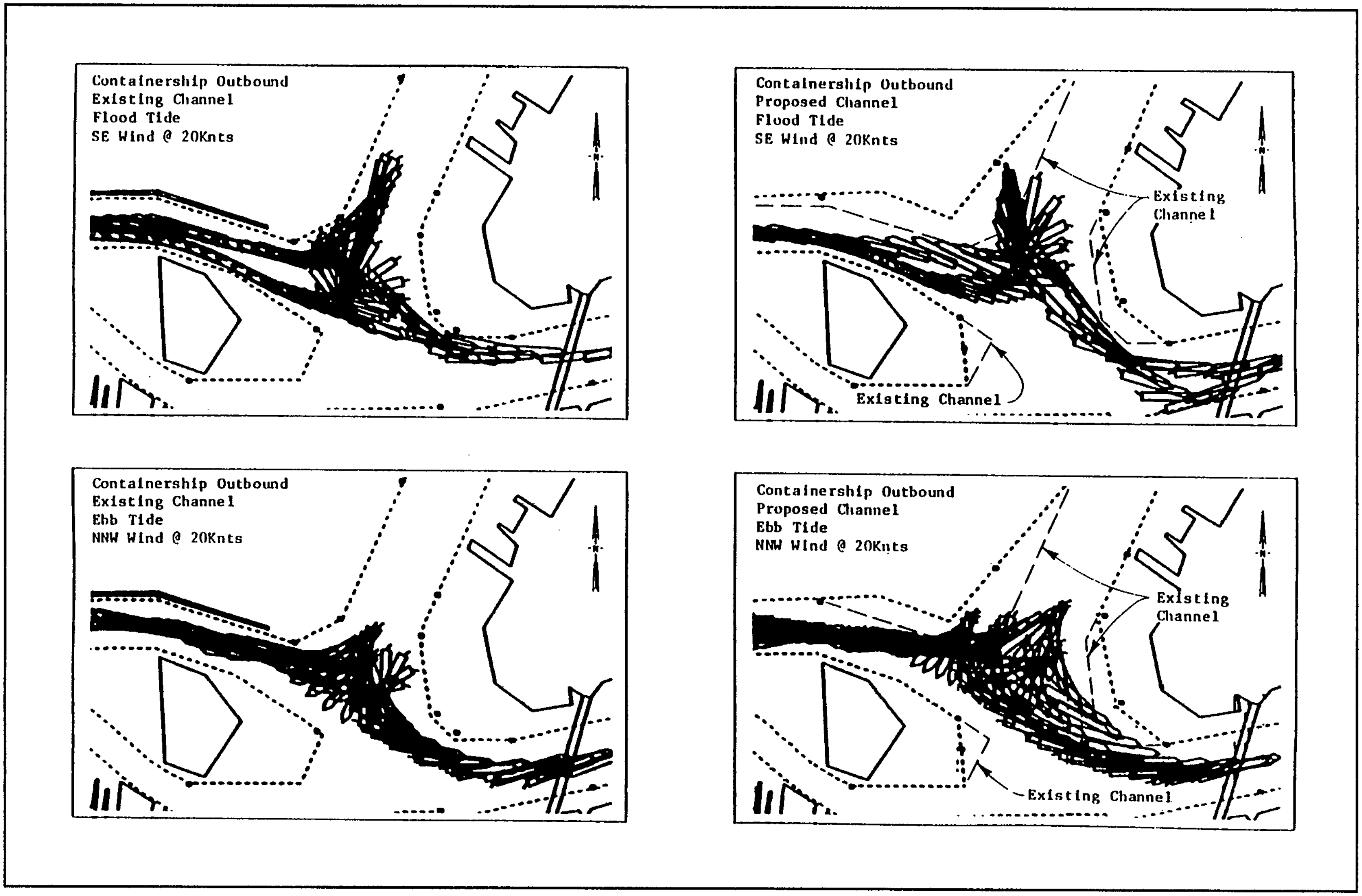


Figure 6. Composite trackplots for outbound AK pilot tests

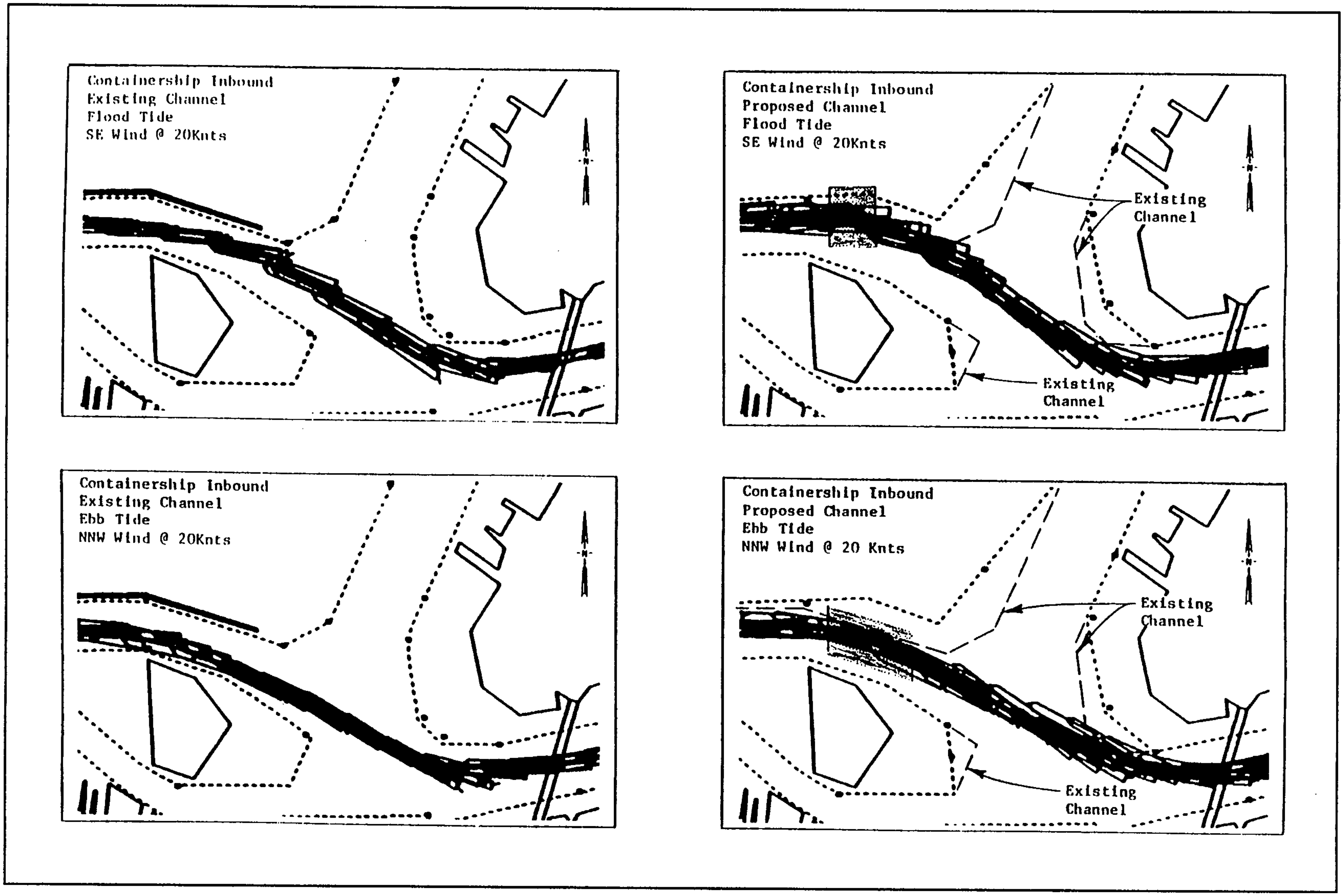


Figure 7. Composite trackplots for inbound AK pilot tests

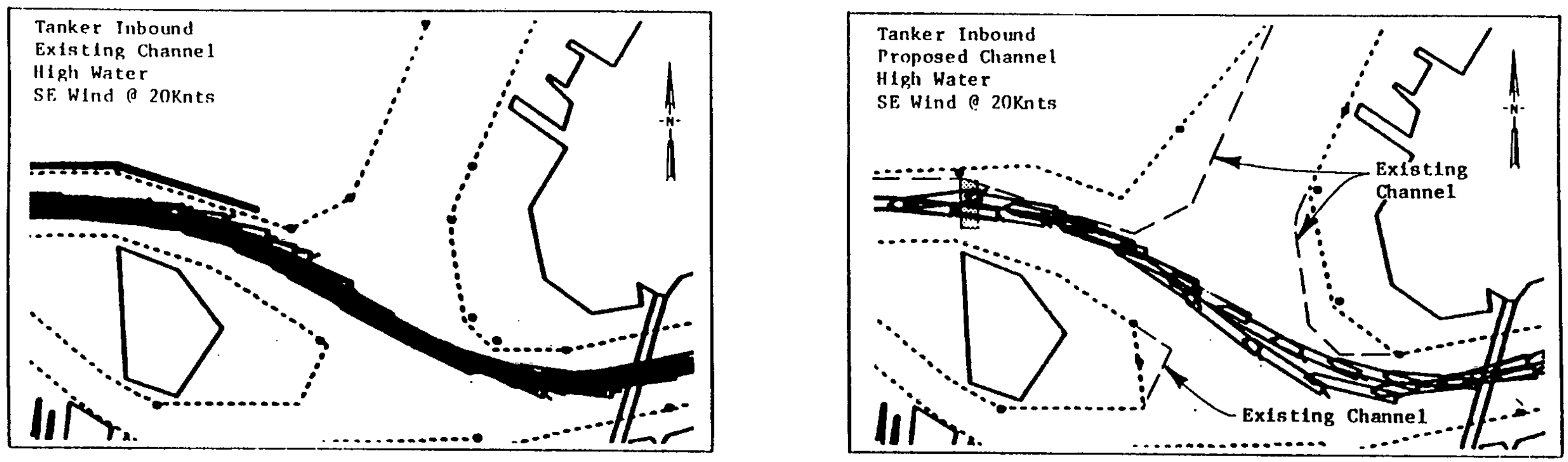


Figure 8. Composite tracklines for inbound AK pilot tests

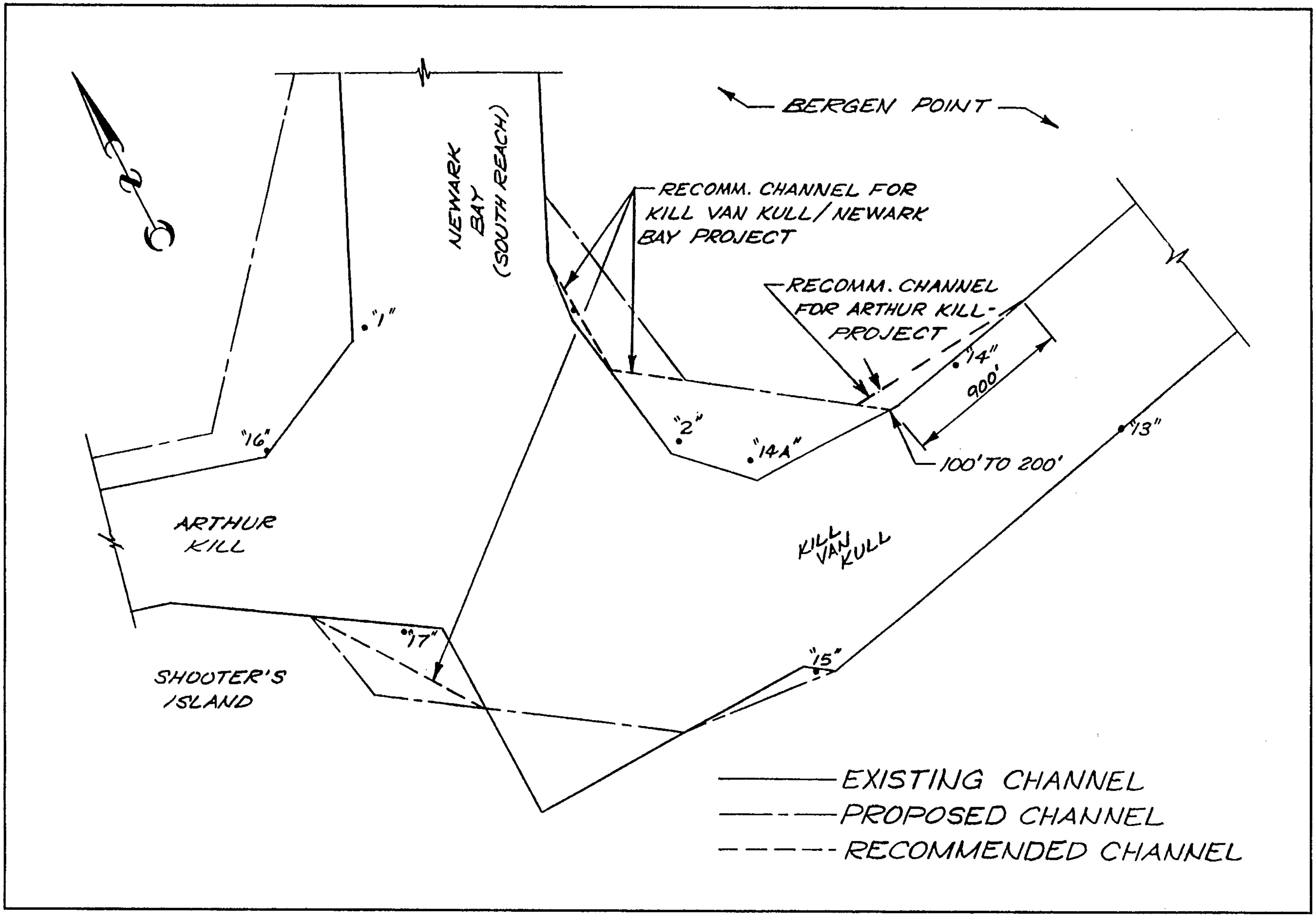


Figure 9. Recommended channel configuration for Bergen Point area

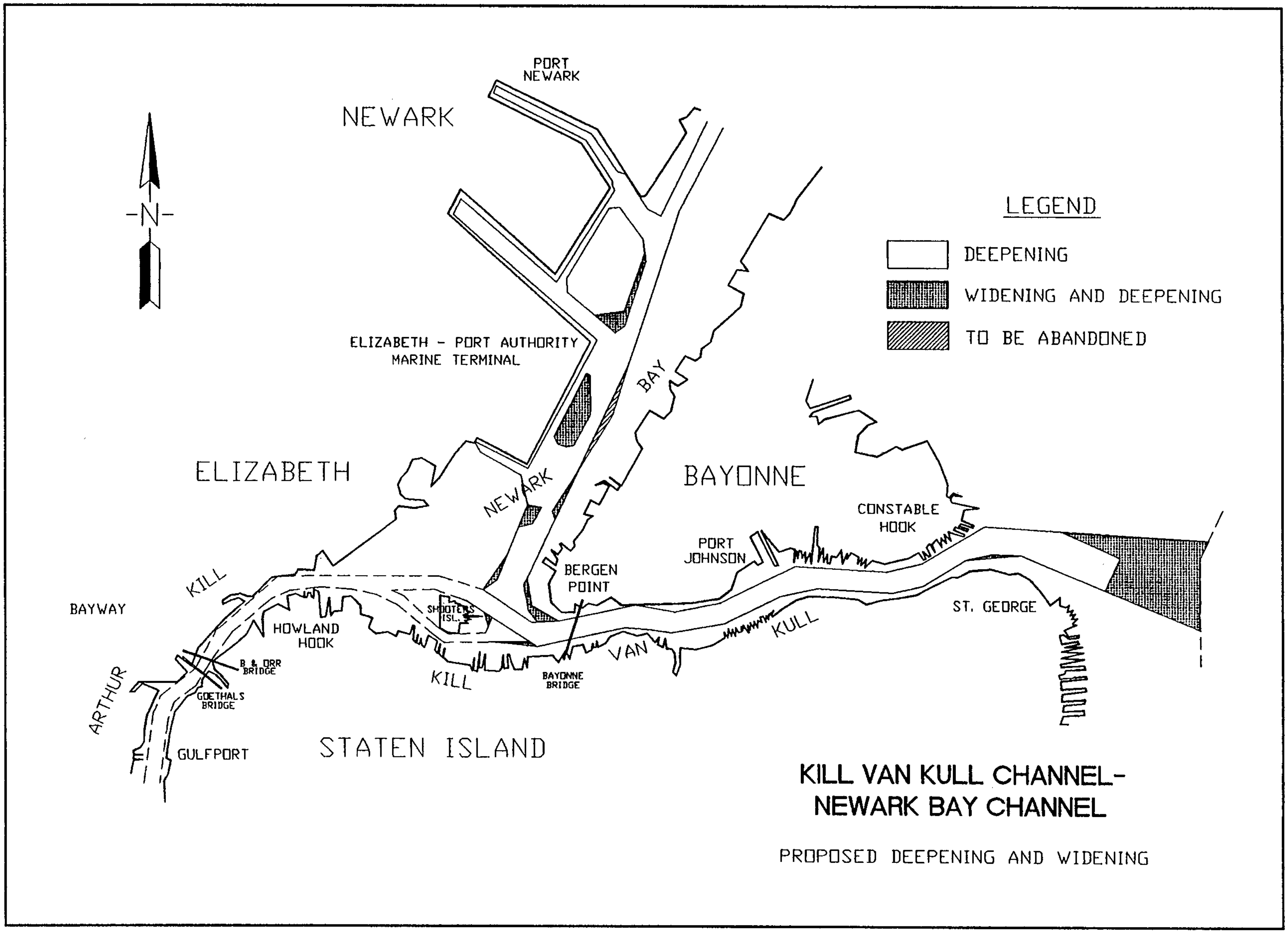


Figure 10. Kill Van Kull Channel study area

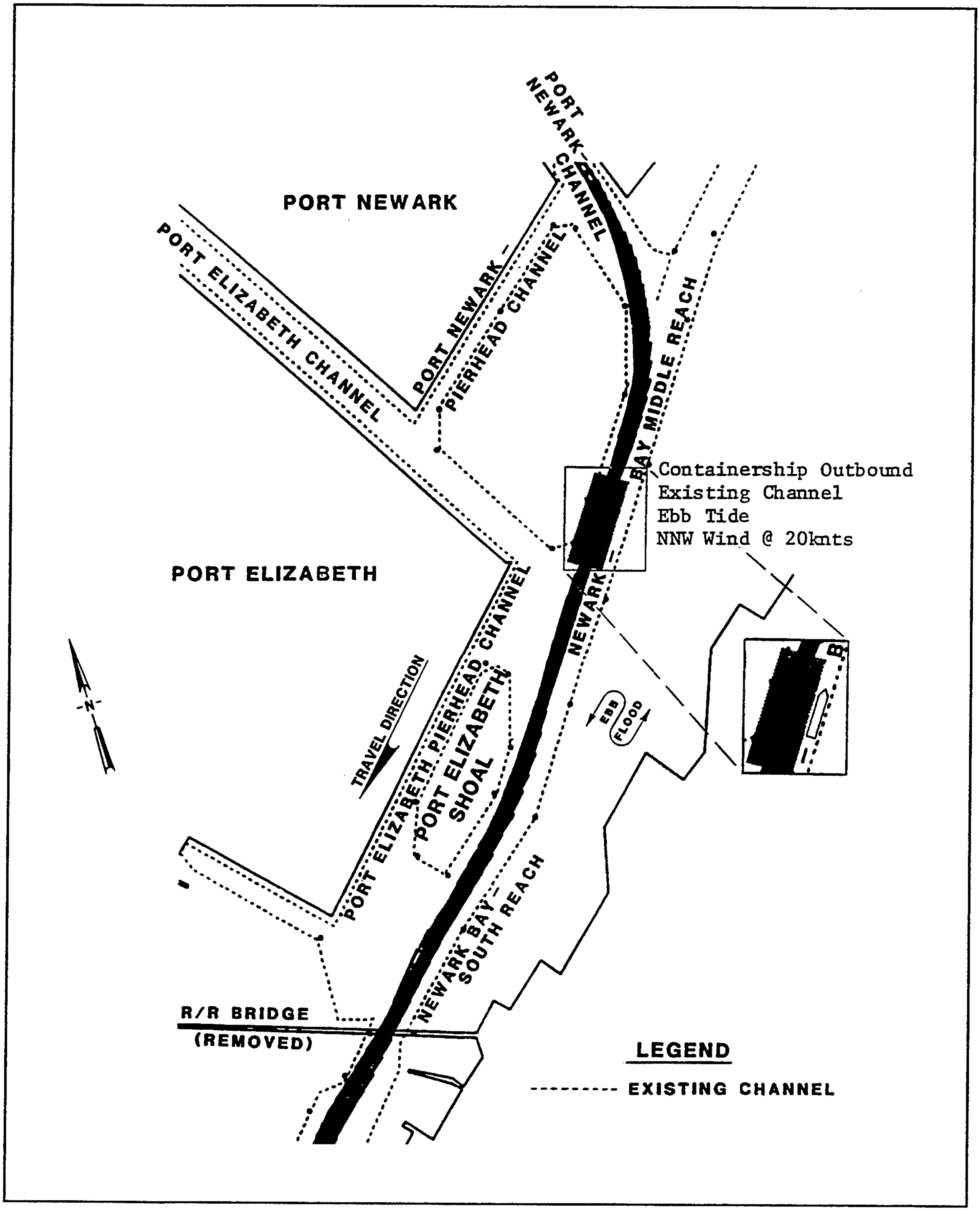


Figure 11. Composite trackplots for simulated outbound existing channel transits

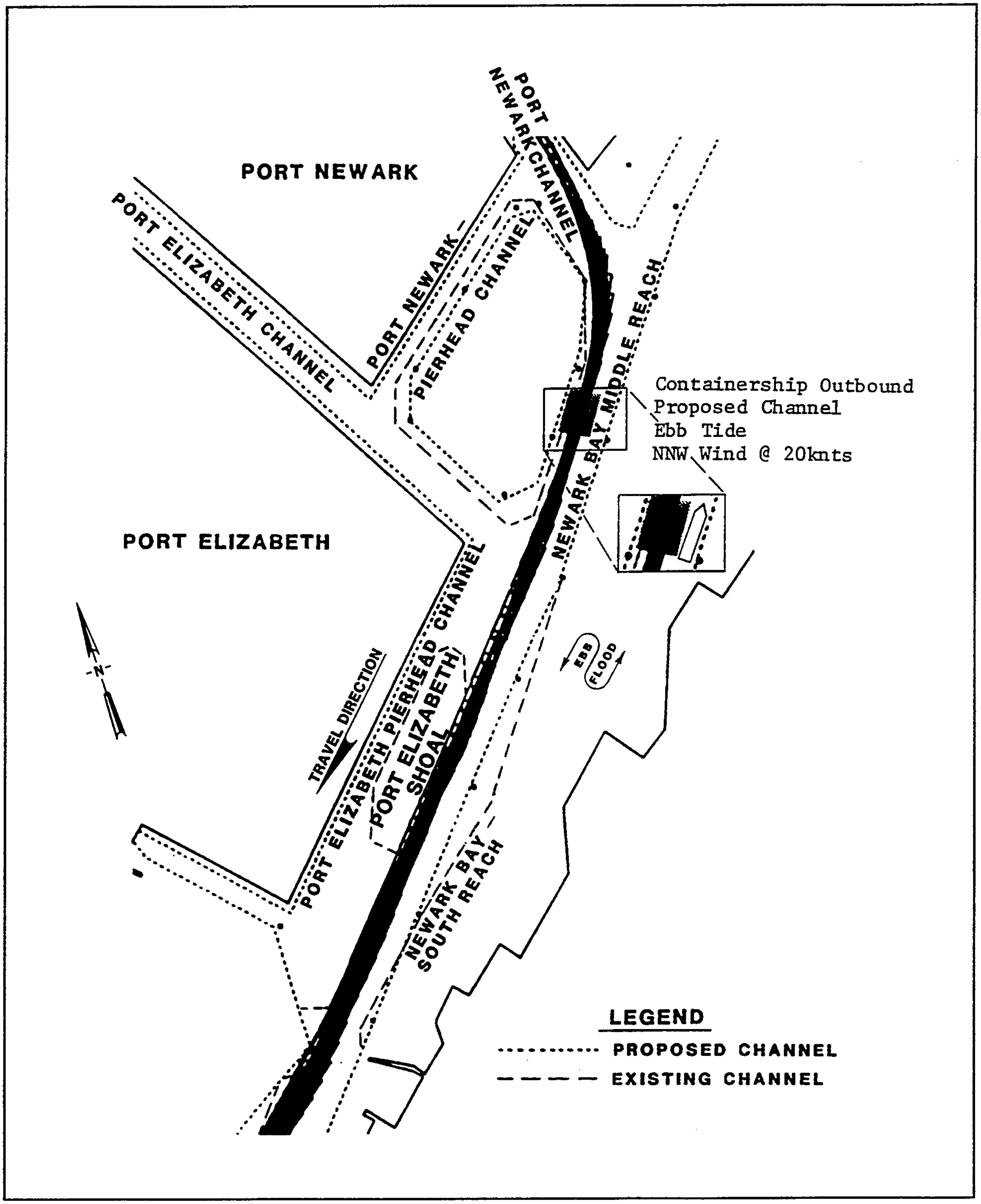


Figure 12. Composite trackplots for simulated outbound proposed channel transits

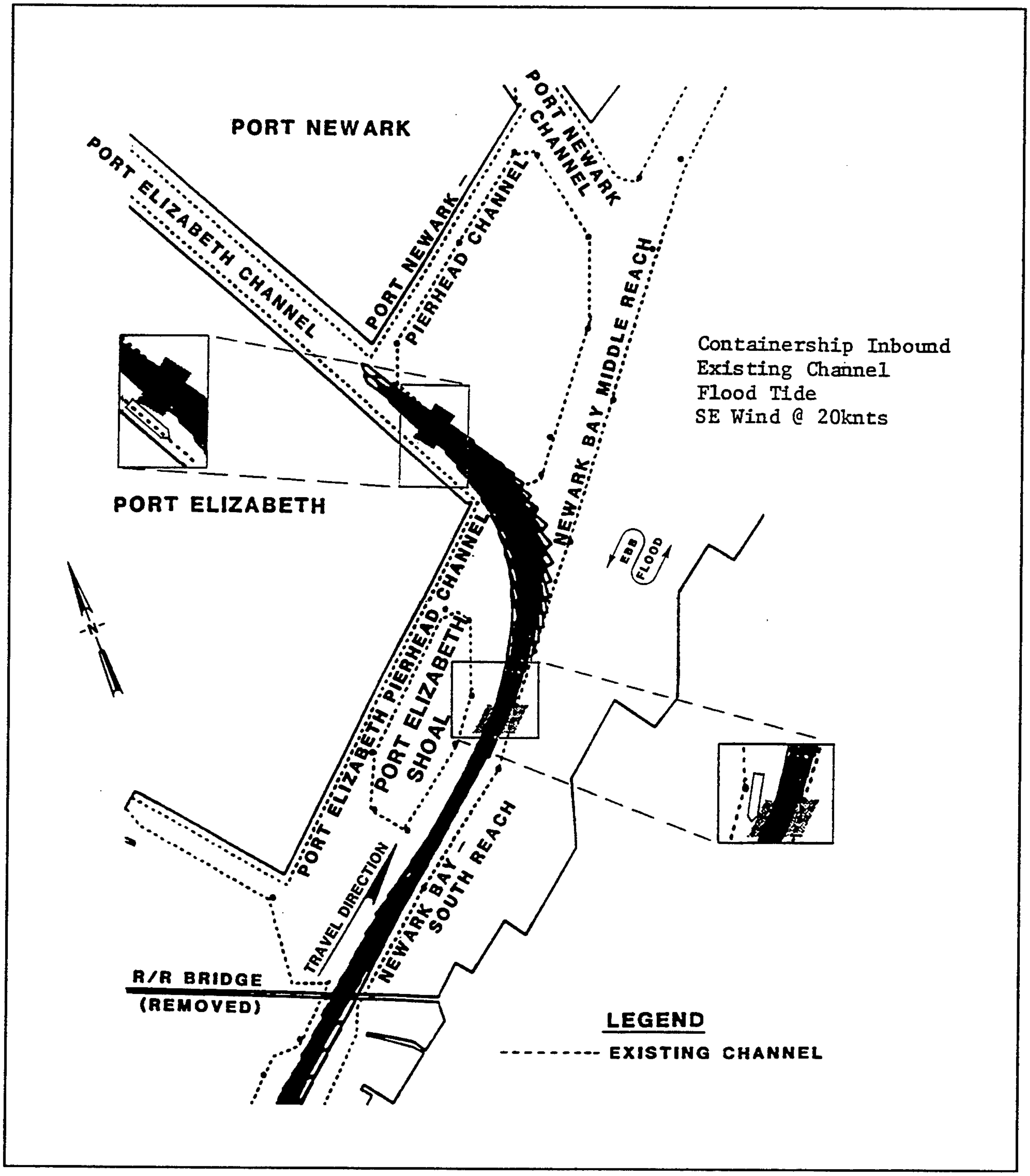


Figure 13. Composite trackplots for simulated inbound channel transits

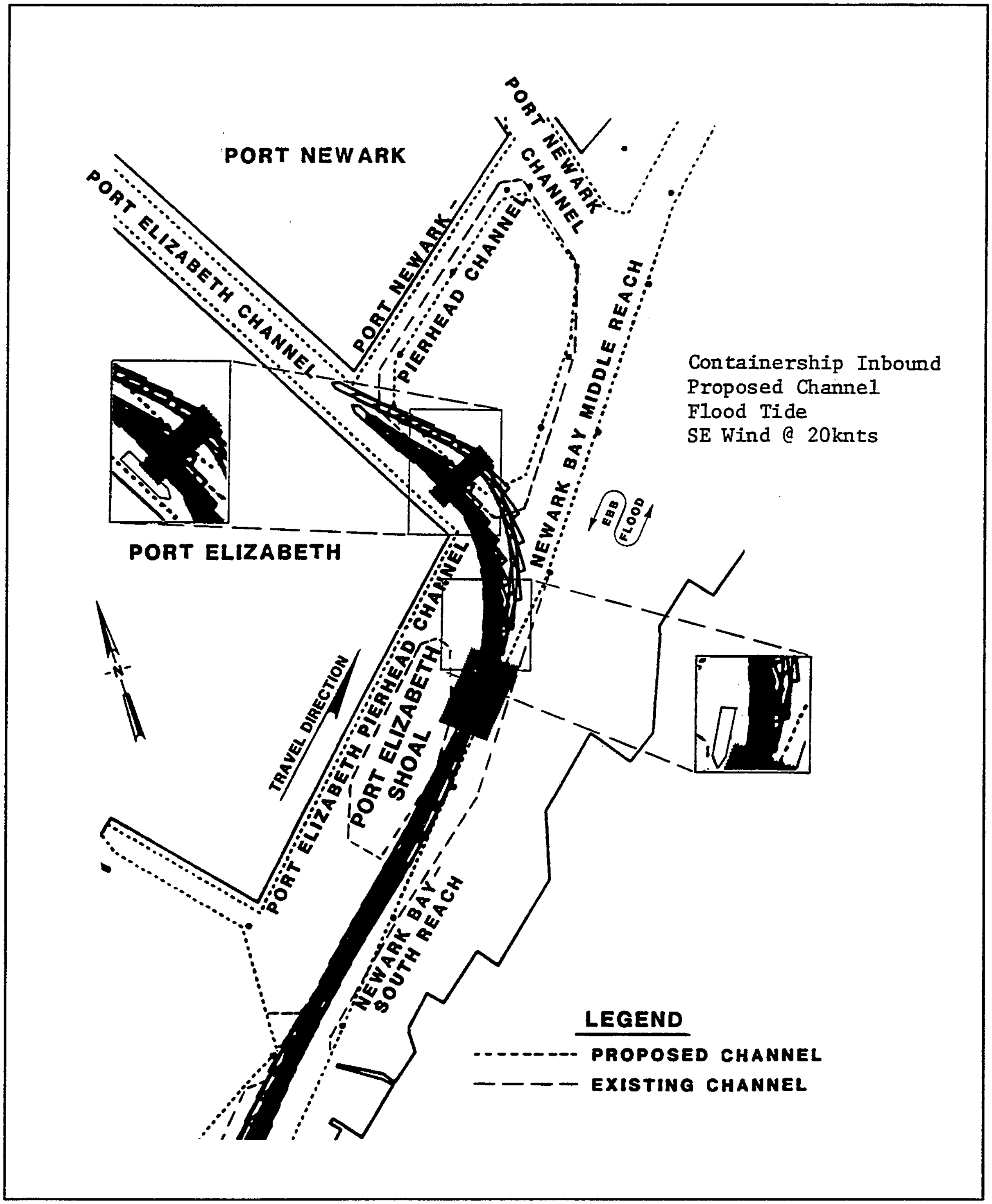
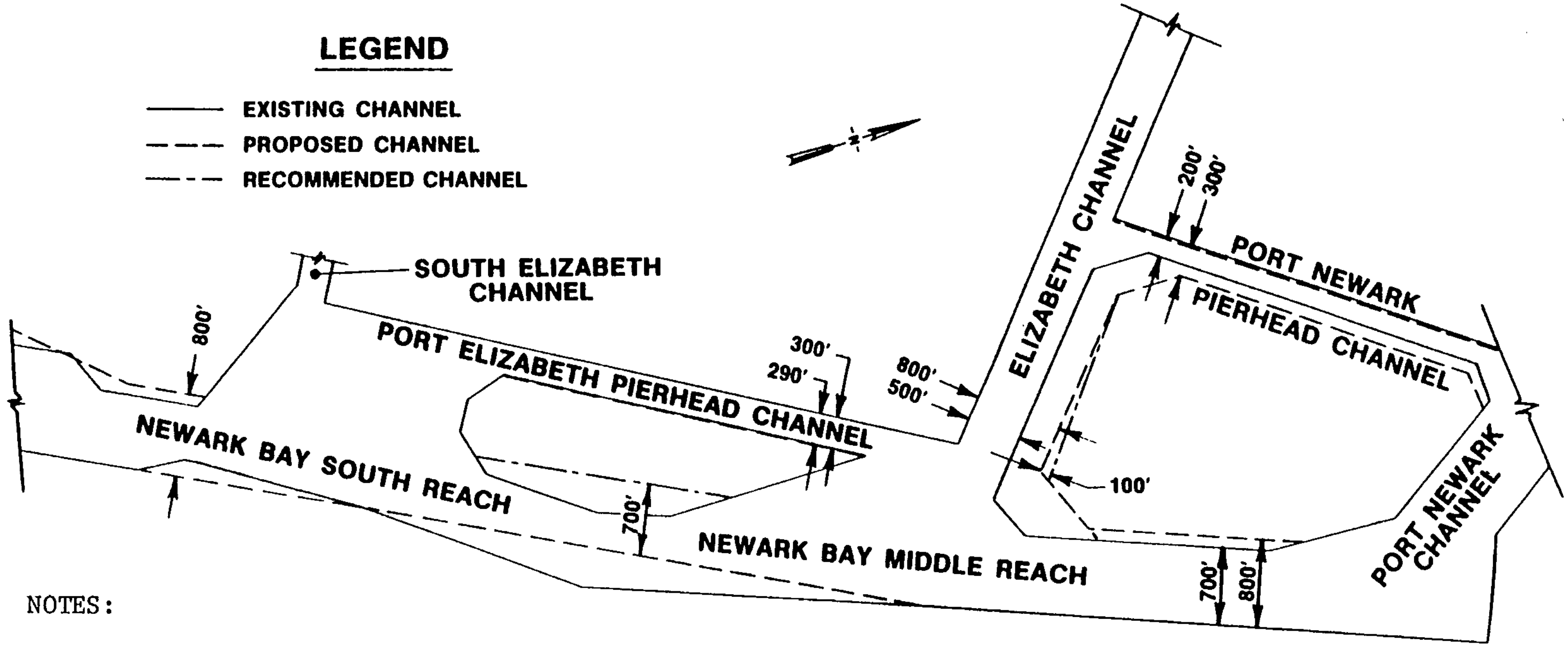


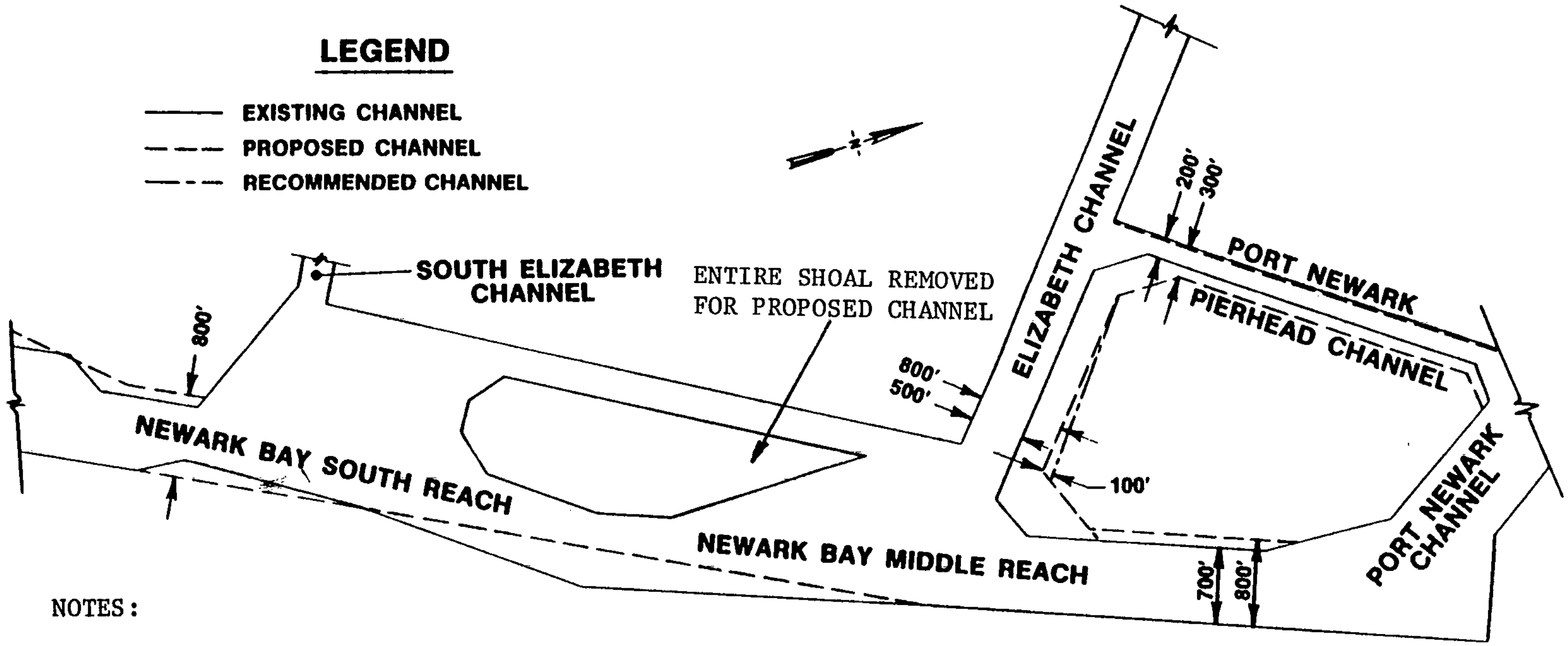
Figure 14. Composite trackplots for simulated inbound proposed channel transits



NOTES:

1. Unless otherwise shown, the recommended channel alignment is the same as the proposed alignment.
2. A width of 700 ft is recommended for the Newark Bay Main Channel north of the former Central Railroad of New Jersey bridge.

Figure 15. Newark Bay Channels without removal of Port Elizabeth Shoal



NOTES:

1. Unless otherwise shown, the recommended channel alignment is the same as the proposed alignment.
2. A width of 700 ft is recommended for the Newark Bay Main Channel north of the former Central Railroad of New Jersey bridge.

Figure 16. Newark Bay Channels with removal of Port Elizabeth Shoal

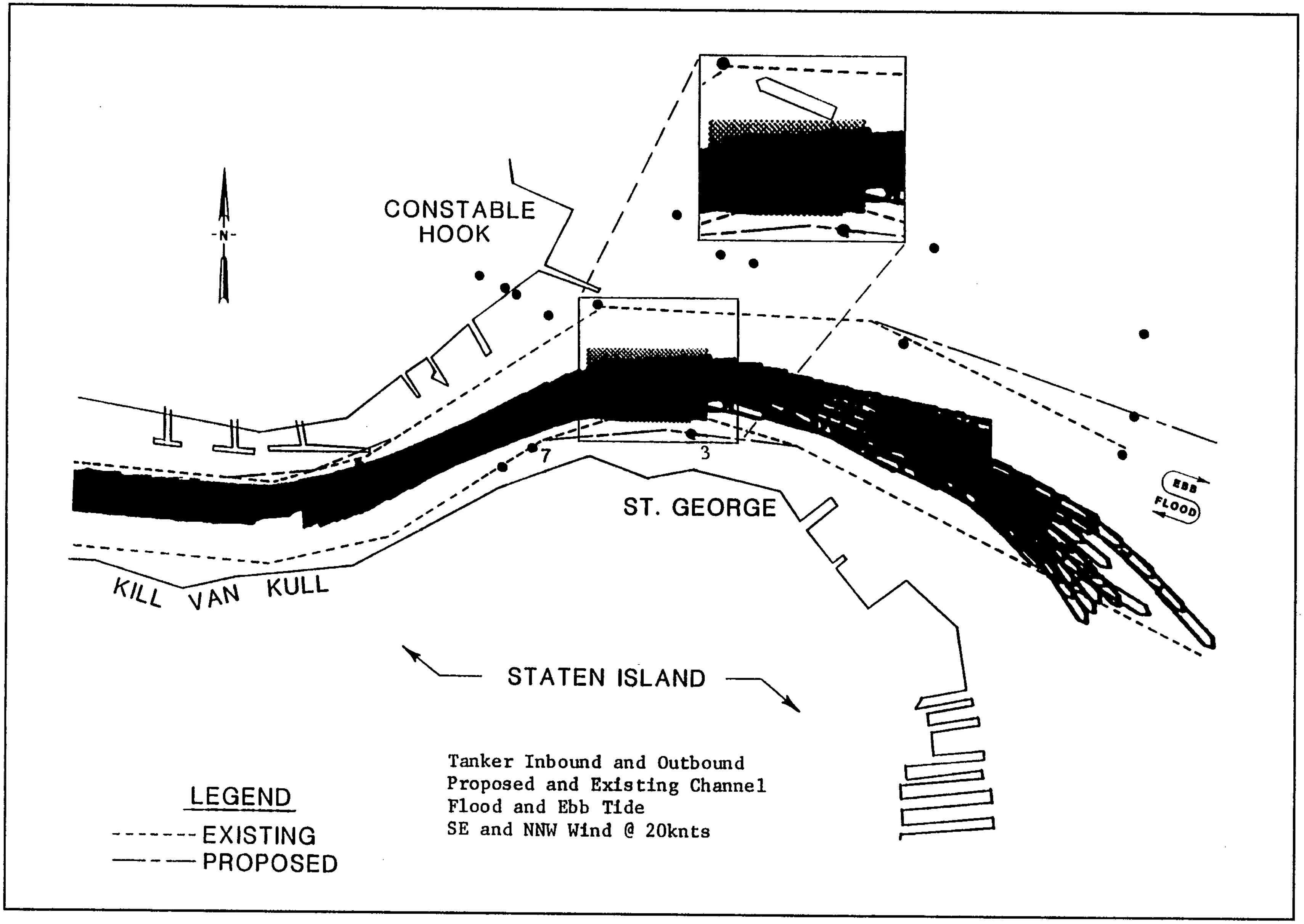


Figure 17. Composite trackplots in the Kill Van Kull Entrance

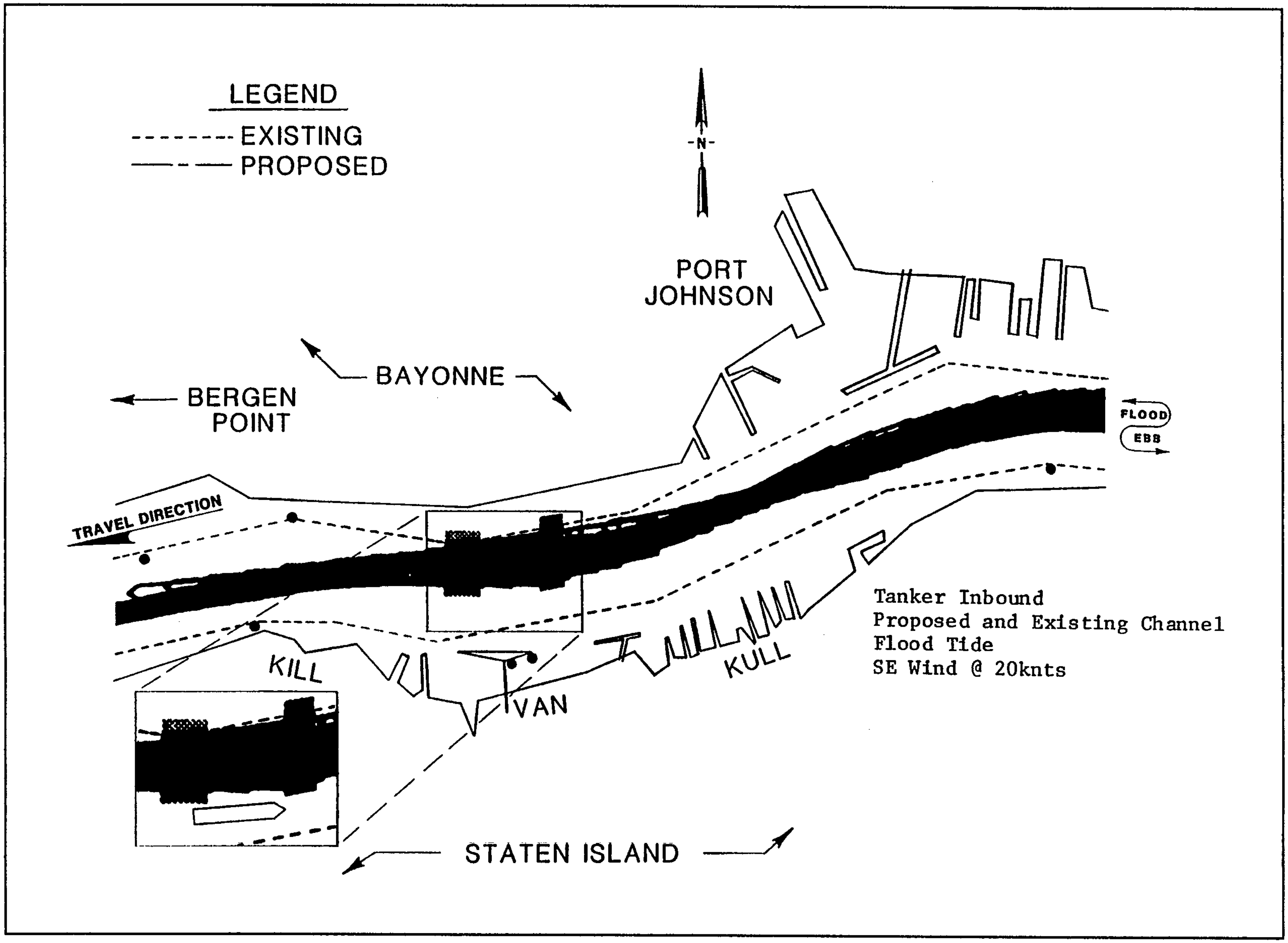


Figure 18. Composite trackplots in Bergen Point East Reach

Appendix A Contractor Study Recommendations For Kill Van Kull Simulation Study

Recommendations

The following recommendations are predicated on the deepening of all channels to a project depth of 40 ft MLW and are based solely on an analysis of the track plots, numerical data, and review of the pilots' responses to questionnaires.

Widening at Entrance to Kill Van Kull and Widening of Outer Bend of Constable Hook. Based on observations summarized above, the planned channel improvements are not necessary to obtain safe navigation conditions.

Widening of the 130 Degree Bend at the Junction of Kill Van Kull and Newark Bay at Bergen Point. All observations and analyses support the merits of the proposed widening. This is consistent with results reported in Reference 1. However, all analyses and pilot recommendations support widening only at the west entrance to Newark bay, immediately north of Shooters Island. Accordingly, the planned widening at Bergen Point is not recommended.

The planned channel changes. The following planned channel changes had no effect on the simulated transits and are not necessary to obtain safe navigation conditions:

a. Widening of the channel through the Central Railroad of New Jersey bridge.

b. Widening of the Port Elizabeth Pierhead channel.

c. Widening of the Newark Bay main channel and removal of the "dog leg" at buoy 8.

Widening of the Bend at the Entrance to Port Elizabeth Channel. As noted earlier, the proposed widening had some beneficial effect on inbound; therefore, it is recommended.

In addition to the above recommendations, consideration should be given to the following transit restrictions to minimize the incidence of marginal or casualty events in the two troubled areas:

a. South channel boundary, Bergen Point West Reach, at the Bayonne Bridge

(1) Restrict presence of traffic ships holding at the Bayonne Bridge.

(2) Restrict outbound traffic on the ebb tide.

(3) Provide pilot training for outbound transits which include the rounding at Bergen Point.

b. North channel boundary, Port Elizabeth

(1) Restrict presence of outbound traffic ships in way of inbound transits to Port Elizabeth channel.

(2) Provide pilot training for inbound transits which include the turn into Port Elizabeth Channel.

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13. ABSTRACT *(Maximum 200 words)*

A ship simulation study was performed for the U.S. Army Engineer District, New York, to establish design guidance for the construction of a deepened and partially widened deep-draft navigation channel in the Arthur Kill, Kill Van Kull, and Newark Bay harbors. The study was performed on the Computer Aided Operations Research Facility operated by Marine Safety International at Kings Point, New York. The U.S. Army Engineer Waterways Experiment Station developed the numerical model working with Tracor Hydronautics, Inc., the contractor who performed the investigation and simulation tests, in analyzing the results and evaluating the design. This report summarizes the results and recommendations of this study.

14. SUBJECT TERMS

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Channel design	Kill Van Kull	New York
Channel dimensions	Modeling	Newark Bay
Channel layout	Navigation	Simulation

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